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Original Article

Correlative variation of economically valuable traits in South Kazakh Merino

Variação correlativa de características economicamente valiosas no sul do Cazaque Merino

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Abstract

Fine-fleeced sheep are distinguished by numerous economically valuable traits that constitute the foundation for productive distinctions among breeds, populations, lines, and individuals. Many of these traits have already been mentioned or thoroughly examined during studies on the correlative variability of productivity indicators, blood parameters, characteristics of pulmonary gas exchange, histological structures of the skin, and features of the experimental sheep's coat. The objective of our research was to investigate the correlative variability of key economically valuable traits that characterize the overall functional state of sheep organisms under varying environmental conditions. The study was conducted at the "Sharbulak" breeding farms and the "Samat" peasant farms in the Kazygurt district of the Turkestan region. Our findings reveal that one-year-old rams surpass ewes in terms of live weight by 32-37% and in terms of unwashed wool shearing by 21-23%. Two-year-old rams outperform ewes in live weight by 2.15-2.17 times and in unwashed wool shearing by 2.38-2.44 times. The highest phenotypic variability in relative terms (as indicated by the coefficient of variation) is observed in the shearing of pure wool, with an average coefficient of variation of 18.1% across all sex and age groups of sheep. This is followed by the wool coefficient (17.4%) and the yield of pure fiber (12.5%). For each group of animals, the most substantial phenotypic correlation coefficients were observed between the live weight of sheep and the shearing of unwashed wool. On average, across all groups of sheep at the "Sharbulak" breeding farm, this phenotypic correlation reaches +0.411 ± 0.077. Correspondingly, for the sheep herd at the "Samat" peasant farm, it is +0.326 ± 0.075. The second-highest phenotypic correlation pertains to the cut of unwashed wool and the length of wool (with correlation coefficients of +0.156 ± 0.058 and +0.145 ± 0.057, respectively, for the herds). The third-highest correlation involves live weight and wool length (+0.131 ± 0.085 and +0.105 ± 0.078, respectively). No statistically significant differences were identified in the average correlation coefficients between the live weight of sheep, the shearing of unwashed wool, and the length of the staple among the flocks of sheep at the "Sharbulak" breeding farm and the "Samat" peasant farm.

Keywords: sheep, correlation, variability, unwashed wool shearing, wool length, live weight, pure fiber yield, pure wool shearing, coefficient of variation, wooliness coefficient.

Resumo

Ovelhas de lã fina distinguem-se por numerosas características economicamente valiosas que constituem a base para distinções produtivas entre raças, populações, linhagens e indivíduos. Muitas dessas características já foram mencionadas ou examinadas minuciosamente durante estudos sobre a variabilidade correlativa de indicadores de produtividade, parâmetros sanguíneos, características das trocas gasosas pulmonares, estruturas histológicas da pele e características da pelagem experimental da ovelha. O objetivo da nossa pesquisa foi investigar a variabilidade correlativa das principais características economicamente valiosas que caracterizam o estado funcional geral dos organismos ovinos sob diversas condições ambientais. O estudo foi realizado nas fazendas de criação "Sharbulak" e nas fazendas camponesas "Samat" no distrito de Kazygurt, na região do Turquestão. Nossas descobertas revelam que os carneiros com um ano de idade superam as ovelhas em termos de peso vivo em 32-37%, e em termos de tosquia de lã não lavada, em 21-23%. Carneiros de dois anos superam as ovelhas em peso vivo em 2,15-2,17 vezes, e em tosquia de lã não lavada, em 2,38-2,44 vezes. A maior variabilidade fenotípica em termos relativos (conforme indicado pelo coeficiente de variação) é observada na tosquia de lã pura, com um coeficiente de variação médio de 18,1% em todos os sexos e faixas etárias das ovelhas. Seguem-se o coeficiente de lã (17,4%) e o rendimento de fibra pura (12,5%). Para cada grupo de animais, foram observados os coeficientes de correlação fenotípica mais substanciais entre o peso vivo dos ovinos e a tosquia da lã não lavada. Em média, em todos os grupos de ovinos da

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exploração de criação "Sharbulak", esta correlação fenotípica atinge +0,411 ± 0,077. Correspondentemente, para o rebanho ovino da fazenda camponesa "Samat", é de +0,326 ± 0,075. A segunda maior correlação fenotípica refere-se ao corte da lã não lavada e ao comprimento da lã (com coeficientes de correlação de +0,156 ± 0,058 e +0,145 ± 0,057, respectivamente, para os rebanhos). A terceira maior correlação envolve peso vivo e comprimento da lã (+0,131 ± 0,085 e +0,105 ± 0,078, respectivamente). Não foram identificadas diferenças estatisticamente significativas nos coeficientes de correlação médios entre o peso vivo dos ovinos, a tosquia da lã não lavada e o comprimento do alimento básico entre os rebanhos de ovinos da quinta de criação "Sharbulak" e da quinta camponesa "Samat".

Palavras-chave: ovinos, correlação, variabilidade, tosquia de lã não lavada, comprimento de lã, peso vivo, rendimento de fibra pura, tosquia de lã pura, coeficiente de variação, coeficiente de lanosidade.

1. Introduction

Sheep breeding stands as one of the most vital sectors within global animal husbandry. The hereditary inclinations of bred sheep organisms are significantly impacted by their environment. This underscores the necessity of discerning the extent to which hereditary factors influence the development of phenotypic trait diversity (FAO, 2023). Present statistics reveal an ongoing rise in the number of sheep and goat breeds along with their geographical distribution. Sheep and goats are found across the world, with notable concentrations in Africa and the Americas - approximately 850.0 million and 930.0 million, respectively. Meanwhile, Asia, Europe, and Oceania collectively harbor 173.0 million sheep and 67.0 million goats. As of the close of 2020, the Russian Federation boasted approximately 22.0 million sheep. Among the key global products in these industries, the production of mutton and goat meat stands out (yielding sales of 37.0 and 25.0 billion dollars, respectively). Additionally, the economic value of sheep and goat milk worldwide reached 5.6 and 6.4 billion dollars, respectively (FAO, 2023).

In the broader scope of global meat consumption, international trade in mutton accounts for a limited 7% of total production. The majority of mutton exports on the world market originate from the southern hemisphere, with New Zealand contributing 47% and Australia 36% of the total. These exports are primarily directed towards the European Union, North Asia, the Middle East, and North America. In numerous regions, particularly temperate ones, sheep and goat meat reign as the most consumed products (FAO, 2023).

Simultaneously, notable significance in the progression of animal breeds is attributed not only to conventional breeding methods such as selection, culling, and pairing, but also to the intricate methodology of complex breeding. This approach hinges on a genetic analysis of the selected traits and their interrelations.

Within the realm of breeding endeavors, the outcome of selection is intricately tied to the array of traits and the inherent dynamics of their interplay. The bedrock of the breeding process, encompassing breed creation and refinement, lies in the reconfiguration of correlation systems (Cognie et al., 2003). It should be emphasized, however, that accurate assessment and adept utilization of these systems are pivotal for the triumphant execution of purposeful selection and pairing strategies.

Of particular scientific and practical significance lies the early anticipation of meat and wool productivity, reproductive traits, and resistance indicators in sheep (Ostapchuk et al., 2018; Pogodaev et al., 2021a, b). There exists evidence that animals of diverse breeds and productivity orientations exhibit specific correlations among individual traits, indicative of their hereditary nature. Hence, correlation coefficients can be used as objective indicators applicable to the population from which they are derived (Azhimetov et al., 2020a, b; Davletova, 2013).

Thus, in Australian Merino sheep, there is a positive correlation between pure wool shearing and live weight ($r = 0.37$), pure wool shearing and wool length ($r = 0.47$) (Kolosov, 2012).

When studying the population of sheep of the Kuibyshev breed, a positive, but somewhat weak degree of correlation coefficient with live weight and shearing of unwashed wool was established ($r = 0.329$); body weight and wool length ($r = 0.079$); unwashed wool shearing and wool length ($r=0.269$) and other considered features (Yerokhin, 2014).

Similar results were noted in fat-tailed sheep with bleached wool, where a positive correlation was found between live weight and wool shearing in ewes and gimmers (Pogodaev et al., 2019, 2020; Tindano et al., 2017). In recent decades, biotechnological methods of directed regulation of reproductive function have become increasingly important in the practice of reproduction of farm animals (Tsegay et al., 2013).

On one hand, the rise in sheep and goat populations stems from a pivotal attribute of small ruminants - their ability to thrive and yield diverse, high-quality products even in unfavorable or, at times, otherwise untenable environments for other categories of livestock. On the flip side, the surge in small ruminant breeding over recent decades has been propelled by the advancement and enhancement of assisted reproductive technologies.

In the contemporary landscape, ensuring the profitability of sheep breeding within the Republic of Kazakhstan hinges on the establishment of highly productive herds endowed with a substantial genetic potential, thus enabling its effective implementation within specific natural and climatic zones. Within the Turkestan region, fine-wool sheep predominantly consist of individuals from the South Kazakh Merino breed, oriented towards both wool and meat production streams.

The results achieved in sheep breeding in the Turkestan region cannot be considered high due to the insignificant proportion of fine and even wool. In addition, quality indicators and wool shearing vary greatly from year to year. An increase in the modification variability of traits does not allow an accurate assessment of the genotype of animals by their phenotype and, as a result, the efficiency of breeding work decreases. The main reasons can be called insufficiently clear concretization of the selected traits for individual varieties of fine wool, an incomplete understanding of the gradations of the length of wool in certain parts of the body of animals, the lack of development of perfect genetic breeding methods, poor knowledge of the features of variability, heritability and the relationship of the selected traits.

Theoretical concepts of correlative variability serve as the basis for many fundamental generalizations of modern biology and zootechnics. Since correlative variability is of a general biological nature, the study of this phenomenon has always been promising in cognitive and applied terms. Therefore, interest in the problem of correlative variability does not weaken in all periods of the development of science (Yakubu, 2010; Malhado et al., 2009).

The correlation between live weight and various indicators of sheep productivity doesn't always exhibit a straightforward or linear pattern. In some cases, this correlation assumes a negative value when expressed in kilograms. The measure of pure fiber shearing is contingent on both the weight of a single fiber and the number of fibers in a fleece. Factors like wool length and fineness determine the weight of individual fibers, while the density of fibers and the size of the wool field influence the fiber count in a fleece. These latter aspects, in turn, are influenced by factors such as the animal's size, skin wrinkling, and the sheep's overall development. The diverse range of breeding strategies, emphasizing the growth or stabilization of specific components of sheep coats while enhancing productivity in targeted directions, substantially contributes to the particularities of the observed relative variability (Souza et al., 2013; Cardoso et al., 2013).

Numerous investigations have established a connection between the characteristics of the wool-forming structures within the skin and the characteristics of the sheep's coat (Wolf et al., 2014).

Considering that the genetic foundation of breeding rests on variability, comprehending the patterns of variability in productive traits among populations of fine-fleeced sheep of the South Kazakh Merino breed holds paramount importance for both theoretical and practical breeding purposes.

Fine-fleeced sheep exhibit a multitude of economically valuable traits that underlie the productive disparities among breeds, populations, lines, and individual animals. Many of these traits have been previously mentioned or thoroughly explored when investigating the correlative variability between productivity indicators, blood parameters, pulmonary gas exchange attributes, histological skin structures, and characteristics of experimental sheep coats.

This study aims to conduct a correlation analysis involving the key economically valuable features of fine-fleeced sheep within the South Kazakh Merino breed.

2. Material and Methods

Study location. The experimental phase of the study was conducted within the populations of fine-wool sheep belonging to the South Kazakh Merino breed. These populations were situated within the "Sharbulak" breeding farms and the "Samat" peasant farms, both located in the Kazygurt district of the Turkestan region.

Objects of research. The object of experimental study is purebred sheep of South Kazakh merino with the number of 25175 animals including: I - stud rams (2 years) 418 animals; II - replacement stud rams (yearlings) 2347 animals; III - stud rams for sale (yearlings) 7910 animals; IV - ewes (4 years) 8010 animals; V - gimmers (yearlings) 6190 animals. All stud rams and ewes used in the experiment met the requirements for animals of elite and I class.

In the evaluation and shearing of fine-fleeced sheep, traditional considerations encompass the following attributes: skin wrinkling, fleece density, staple length, wool crimp, wool fineness, wool evenness in fineness, grease amount and color, sheep covering, external features, live weight, and unwashed wool shearing.

Among the listed characteristics of sheep productivity, only three aspects are measured objectively: live weight, unwashed wool shear, and staple length. These measurements are consistently implemented across all breeding farms. Consequently, three more objectively measured features are introduced: pure fiber yield, pure wool shearing, and the wool coefficient.

To characterize the qualitative traits of the skin and coat, wool samples were procured from four distinct topographic regions of the animal's body (side, thigh, back, belly) among various sex and age groups of primary rams and ewes. A thorough assessment of the fleece was conducted in accordance with the guidelines set forth by established standards and methodological recommendations (GOST, 1991, 2000, 2001). Qualitative (such as fineness, length, strength, grease, sheen, color, crimp) and quantitative (including the percentage of pure fiber yield, shear of washed and unwashed wool) wool indicators were scrutinized based on approved methodologies (Dmitrik et al., 2017; Zavgorodnyaya et al., 2013, 2019).

The data acquired were subjected to biometric analysis using the MS Excel software and the BIOSTAT software package.

3. Results and Discussion

In the "Sharbulak" breeding farm, the laboratory functioned for a long time and now, after a break is resuming its work to determine the percentage of yield of pure fiber. For each sex and age group of registered animals, 6 indicators of productivity were studied for many years of breeding work with herds of sheep of the "Sharbulak" breeding farm and the "Samat" peasant farm.

The results of studying the average level of development and indicators of phenotypic variability of live weight, unwashed wool shearing and staple length in sheep of the "Sharbulak" and "Samat" farms are shown in Table 1.

Based on the tabulated data, it's evident that the productivity level of sheep within each sex and age group is notably high and substantially surpasses the corresponding breed and industry requisites. At the "Sharbulak" breeding

Table 1. Productivity indicators of the recorded sheep livestock of the "Sharbulak" and "Samat" farm.

Sheep group	"Sharbulak"breeding farm			"Samat" peasant farm		
	n	X ± m	Cv	n	X ± m	Cv
Live weight. kg						
I	220	90.0 ± 2.2	8.9	198	86.9 ± 1.12	7.3
II	1100	55.6 ± 0.69	9.0	1242	53.9 ± 0.60	8.5
III	6380	54.3 ± 0.28	12.7	1530	52.5 ± 0.35	11.7
IV	6930	53.9 ± 0.26	10.9	1080	52.1 ± 0.40	6.7
V	3520	38.5 ± 0.31	13.4	2970	37.2 ± 0.31	12.5
Unwashed wool shearing. kg						
I	220	8.12 ± 0.50	15.1	198	8.10 ± 0.42	13.2
II	1100	4.4 ± 0.16	13.3	1342	4.2 ± 0.12	12.6
III	6380	4.3 ± 0.05	17.0	1530	4.1 ± 0.08	13.3
IV	6930	4.2 ± 0.04	14.9	1080	4.2 ± 0.08	11.6
V	3520	4.1 ± 0.06	18.9	2970	4.0 ± 0.06	17.3
Wool length. cm						
I	220	8.50 ± 0.20	9.6	198	8.48 ± 0.17	8.7
II	1100	8.20 ± 0.11	10.9	1342	8.19 ± 0.10	11.0
III	6380	7.91 ± 0.04	11.6	1530	7.87 ± 0.09	11.8
IV	6930	8.00 ± 0.03	9.5	1080	8.00 ± 0.07	7.9
V	3520	7.95 ± 0.06	11.9	2970	7.91 ± 0.07	12.4

Note: I – stud rams (2 years); II – rearing stud rams (year-olds); III – stud rams for sale (year-olds); IV – ewes (4 years); V – gimmers (year-olds); n – number of animals; X – arithmetic mean; m – arithmetic mean error; Cv – the coefficient of variation.

farm, the mean shearing percentage of unwashed wool in relation to the live weight of sheep stands at 12.8%. Variations within individual sex and age groups of animals fall within the range of 11.7% to 14%. A similar pattern holds true for the sheep herd at the "Samat" farm, where these figures account for 13.0%, 11.3%, and 14.7%, respectively. Within the context of average parameters concerning live weight and shearing of unwashed wool, the phenomenon of sexual dimorphism among sheep becomes apparent. For instance, one-year-old rams surpass ewes by 32-37% in terms of live weight and by 21-23% in unwashed wool shearing. In the case of two-year-old rams, they outperform ewes by 2.15-2.17 times in live weight and by 2.38-2.44 times in unwashed wool shearing. These considerable disparities result not solely from sexual dimorphism, but also from varying degrees of selection intensity and growth conditions for both rams and ewes. However, there is little sexual dimorphism with regard to wool length. One-year-old rams exhibit a 2% difference from ewes in terms of this trait's development, while two-year-old rams show an 8-11% difference compared to ewes.

Information pertaining to the mean values and phenotypic variability indicators of pure wool yield, pure fiber shearing, and the wool coefficient for the "Sharbulak" breeding farm's sheep flock are detailed in Table 2.

In general, the average indicators of the characteristics taken into account meet the stud and breed requirements. The highest phenotypic variability in relative terms (in terms of the value of the coefficient of variation) has the shearing of pure wool (variation coefficient) and averages 18.1% for all sex and age groups of sheep, followed by the wool coefficient (17.4%) and the yield of pure fiber (12.5%).

Based on the study of the phenotypic variability of the yield of pure wool, the shearing of pure fiber and the coefficient of wool in the flock of sheep of the "Sharbulak" breeding farm, as well as the live weight, the shearing of unwashed wool and the length of the staple in the sheep of the "Sharbulak" breeding farm and the "Samat" peasant farm, the following can be noted: high individual variability has a pure fiber shear (18.1%), followed by wool ratio (17.4%), unwashed wool shear (13.9-15.6%), pure fiber yield (12.5%), live weight (9.5-10.8%) and staple length (10.2-10.5%).

The system of using individual variability for breeding purposes depends on the nature of the distribution of the phenotypic diversity of animals according to the main economically useful traits. According to the herds of sheep of the "Sharbulak" breeding farm and the "Samat" peasant farm, the distribution of the studied traits has a normal character. Empirical indicators of the χ^2 (chi-square) criterion, established according to sheep productivity data for the last recorded year, practically do not exceed the standard values of χ^2 (chi-square) for the first probability threshold (P_1=0.95) of a significant difference between the empirical frequency distribution variational series and theoretical (normal).

Table 2. Productivity indicators for the recorded sheep population at the "Sharbulak" breeding farm.

Sheep group	Accounted. years	n	Average for all years included		
			X ± m	σ	Cv
Pure wool yield. kg					
I	11	220	58.1 ± 1.16	5.44	8.4
II	11	1100	82.7 ± 0.57	5.14	14.1
III	11	6380	52.4 ± 0.13	5.56	13.6
IV	11	6930	57.0 ± 1.09	6.10	12.5
V	11	3520	53.7 ± 0.20	5.45	10.5
Pure wool shearing. kg					
I	11	220	4.72 ± 0.21	0.97	14.2
II	11	1100	2.32 ± 0.06	0.74	17.2
III	11	6380	2.25 ± 0.01	0.52	20.6
IV	11	6930	2.39 ± 0.09	0.50	16.8
V	11	3520	2.20 ± 0.02	0.59	19.3
Woolness coefficient. g					
I	11	220	57.06 ± 1.80	8.43	9.4
II	11	1100	49.04 ± 1.00	9.08	17.0
III	11	6380	48.83 ± 0.82	9.14	19.4
IV	11	6930	46.76 ± 1.97	11.0	20.7
V	11	3520	56.90 ± 0.43	11.5	17.3

Note: I – stud rams (2 years); II – rearing stud rams (year-olds); III – stud rams for sale (year-olds); IV – ewes (4 years); V – gimmers (year-olds); n – number of animals; X – arithmetic mean; m – arithmetic mean error; Cv – the coefficient of variation.

The results of the study of the correlative variability between the productivity indicators of the sheep population of the "Sharbulak" breeding farm and the "Samat" peasant farm are shown in Table 3.

From the data presented in Table 3, it's evident that the highest phenotypic correlation coefficients across both herds and all animal groups were observed between sheep's live weight and the shearing of unwashed wool. On average, for all sheep groups in the "Sharbulak" breeding farm, the value of this phenotypic correlation reaches +0.411 ± 0.077. In the case of the "Samat" peasant farm's sheep herd, this correlation stands at +0.326 ± 0.075. Following closely in terms of phenotypic correlation are the unwashed wool shearing and wool length, with correlation coefficients of +0.156 ± 0.058 and +0.145 ± 0.057, respectively, for both herds. Live weight and coat length hold the third position, demonstrating correlations of +0.131 ± 0.085 and +0.105 ± 0.078, respectively. Importantly, no statistically significant differences were detected between the average correlation coefficients for live weight, unwashed wool shearing, and staple length between the sheep flocks at the "Sharbulak" breeding farm and the "Samat" peasant farm.

Within the examined traits, negative correlations are observed for three pairs: sheep live weight and pure fiber yield, live weight and wool coefficient, and unwashed wool shearing and pure fiber yield. Conversely, positive correlations are established for the remaining nine pairs. On average, across all sheep groups, the highest positive phenotypic correlation is found between pure fiber shearing and wool coefficient (+0.821 ± 0.020). Subsequent correlations are as follows: unwashed wool shearing and pure fiber shearing (+0.631 ± 0.035), pure wool yield and pure fiber shearing (+0.547 ± 0.038), pure fiber yield and wool coefficient (+0.547 ± 0.038), unwashed wool shearing and wool coefficient (+0.432 ± 0.041), live weight and pure fiber shearing (+0.271 ± 0.004), staple length and pure fiber shearing (+0.255 ± 0.004), wool length and pure fiber yield (+0.185 ± 0.045), and staple length and wool coefficient (+0.179 ± 0.045). Conversely, the highest negative correlation is found between sheep's live weight and the wool coefficient (-0.310 ± 0.043), followed by the correlation between unwashed wool shearing and pure fiber yield (-0.239 ± 0.044), and finally between live weight and pure wool yield (-0.069 ± 0.045).

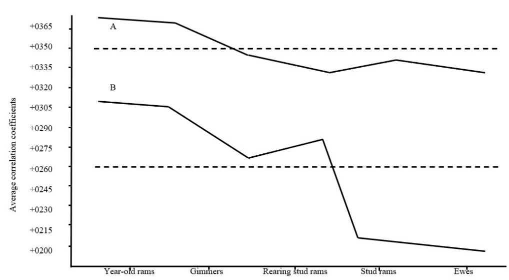
According to the sheep groups of the "Sharbulak" breeding farm, the value of the correlation coefficient between the considered traits is not the same: it is somewhat higher in young animals than in adult animals, i.e. varies approximately in the same way as the magnitude of the correlative variability of live weight, unwashed wool shearing and staple length in sheep of different sex and age groups in the herds of the "Sharbulak" and "Samat" farms. However, this pattern is less pronounced.

The average values of indicators of correlative variability for groups of sheep (Figure 1) were determined by using two sums of correlation coefficients obtained

Table 3. Phenotypic correlations between the productivity indicators of the counted sheep population.

Sheep group	Accounted. years	n	Average for all years included. r_r		
			live weight and wool shearing	live weight and wool length	unwashed wool shearing and staple length
"Sharbulak" breeding farm					
I	11	220	+0.307	-0.019	-0.134
II	11	1100	+0.383	+0.109	+0.071
III	11	6380	+0.579	+0.218	+0.238
IV	11	6930	+0.249	+0.055	-0.042
V	11	3520	+0.537	+0.254	+0.295
Average		3630	+0.411 ± 0.077	+0.131 ± 0.085	+0.156 ± 0.058
"Samat" peasant farm					
I	9	198	+0.143	-0.016	-0.013
II	9	1242	+0.350	+0.064	+0.106
III	9	1530	+0.441	+0.210	+0.146
IV	9	1080	+0.260	+0.003	+0.206
V	9	2970	+0.438	+0.229	+0.254
Average		1404	+0.326 ± 0.075	+0.105 ± 0.078	+0.145 ± 0.057

Note: I – stud rams (2 years); II – rearing stud rams (year-olds); III – stud rams for sale (year-olds); IV – ewes (4 years); V – gimmers (year-olds).



Note: A – without taking into account the signs of the summed correlation coefficients
B – taking into account the signs of the summed correlation coefficients

Figure 1. The average for all years and for all traits the value of the correlation between the productivity indicators of various groups of sheep in the "Sharbulak" breeding farm.

with and without taking into account the signs of these coefficients. If we summarize all the correlation coefficients without taking into account the sign, then the highest average total correlation coefficients between 15 pairs of traits were obtained for the group of year-old rams for sale (0.370 ± 0.027), followed by gimmers (0.369 ± 0.046), rearing year-old rams (0.342 ± 0.097), stud rams (0.335 ± 0.211) and ewes (0.326 ± 0.071). On average, for all groups of sheep, the value of this correlation is 0.346 ± 0.046. If the indicators of correlative variability are summarized taking into account the sign, then the average total correlation coefficients significantly decrease both in general for the entire population of sheep (+0.258 ± 0.048), and for each sex and age group of animals: year-old rams for sale (+0.308 ± 0.028), gimmers (+0.298 ± 0.219) and ewes (+0.197 ± 0.074).

The total average correlation coefficient for all groups of sheep decreased by 25.2%. The decrease in the average correlation value for each sex and age group of sheep ranged from 14.4 to 39.6%, although there is significant parallelism between the ranked rows of sheep groups in terms of the average total correlation coefficients obtained with and without taking into account the signs of correlation (r_s = +0.829 ± 0.280). It follows from the data obtained that at the level of the whole organism of sheep of different sex and age groups, there is a relatively stable (in modulus) system of correlation between the characteristics taken into account. This correlation system is characterized by the fact that, firstly, with an increase in positive correlation, the value of the correlation decreases (r_s = -0.728 ± 0.342) and the total (modulo) indicator of the correlative variability of economically useful traits increases (r_s = +0.829 ± 0.280); secondly, with an increase in negative correlation, both the positive value of the correlation (r_s= -0.728 ± 0.342) and the total (modulo) conjugate variability of features (r_s= -0.925 ± 0.219) decrease.

It should be noted that the magnitude of the correlative variability of various indicators within the correlation system of the integrity of the sheep organism depends both on the specifics of sheep groups in the population and on the characteristics of the traits themselves (Figure 2). For example, the highest (modulo) value of the correlation was observed for the pure fiber shearing (0.505 ± 0.039), followed by: wool coefficient (0.458 ± 0.041), unwashed wool shearing (0.372 ± 0.048), pure fiber yield (0.318 ± 0.043), live weight (0.236 ± 0.050) and wool length (0.183 ± 0.051). When adding the indicators of correlative variability, taking into account the sign, the total correlation of pure

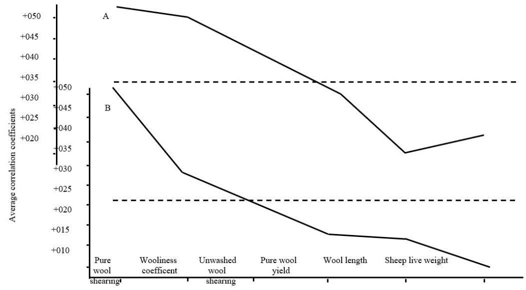


Figure 2. Average for all years and for all groups of sheep, the value of the correlation of each of the characteristics taken into account with the rest of the productivity indicators of sheep in the "Sharbulak" breeding farm. Note: A – without taking into account the signs of the summed correlation coefficients; B – taking into account the signs of the summed correlation coefficients.

wool shearing with other features did not change (+0.505 ± 0.039). Whereas the value of this indicator significantly decreased in terms of wool coefficient (+0.334 ± 0.043), unwashed wool shearing (0.264 ± 0.050), pure fiber yield (+0.194 ± 0.045), wool length (+0.170 ± 0.051) and live weight (+0.083 ± 0.052). The rank correlation between the value of the total indicators of correlative variability, obtained by adding modulo and taking into account the sign, is +0.943 ± 0.167.

However, it's important to note that despite the high rank correlation values, these cannot necessarily be interpreted as indicative of uniform changes. Typically, a higher absolute value of the average total correlation within a group signifies less fluctuation when calculating the average, considering the sign of the correlation. This phenomenon arises due to the relatively lower presence of negative correlations within the correlation system of that specific trait group. For instance, the group focusing on pure wool shearing exhibited the highest average total correlation coefficient in absolute value, which remained unchanged when compared to the average value calculated with the sign of the correlation coefficients. In contrast, for live weight, which ranks second-to-last in the ordered series of mean absolute correlation variability indicators, the correlation value decreased by 64.8% during the calculation. In creating average correlation coefficients, the total absolute balance between positive and negative components inversely affects the outcome.

In a broader sense, it's worth highlighting that the overall patterns of correlative variability at the organism-wide level are also reflected in the magnitudes and directions of correlations between pairs of sheep productivity indicators within the "Sharbulak" breeding farm. This range of fluctuations for these correlative variability indicators has substantially expanded in comparison to the two preceding groups containing 90 average correlation coefficients. These coefficients encompassed a total of 1095 correlation measurements spanning all years, all sheep groups, and all assessed traits. The ratio between the maximum average (absolute) correlative variability indicator and the minimum stands at 1.13 for sheep groups, 2.76 for trait groups, and 11.9 for trait pairs. Therefore, the relative stability of the correlation system across different sex and age groups of sheep is rooted in a broader spectrum of correlation indicators for trait groups and a significant enlargement of correlation ranges for comparable sheep productivity indicators. Consequently, the positive correlation coefficients range from +0.100 ± 0.055 to +0.821 ± 0.020, while negative ones span from -0.069 ± 0.045 to -0.310 ± 0.043. All these observations pertain to the diversity of correlative variability indicators within various pairs of economically valuable traits in the sheep population at the "Sharbulak" breeding farm.

The distribution of correlation coefficients for all pairs of traits across recorded years for stud rams, rearing rams, and year-old rams at the "Sharbulak" breeding farm exhibits a distinctive pattern characterized by bimodal distributions.

Within all the examined groups of sheep at the "Sharbulak" breeding farm, the intrapleiad relationships involve correlation indicators for three pairs of traits: pure fiber shear and wooliness coefficient, pure wool shearing and pure fiber yield, and wooliness coefficient and pure fiber yield. The correlation coefficients between unwashed wool shearing and pure fiber shearing also fall within the intrapleiad nature of relationships. However, in the case of the correlation between these traits for the group of replacement rams and gimmers, the nature of the relationship leans more towards the mixed type than the intrapleiad type. The mixed type of relationships encompasses the correlation between unwashed wool shearing and sheep live weight, as well as the correlation between the wool coefficient and shearing unwashed wool. The remaining pairs of economically valuable traits represent interpleiad links. The strength of the correlation between certain pairs of traits occasionally shifts towards the mixed type of relationships. For instance, correlations like the ones between sheep live weight and pure fiber shearing, live weight and wooliness coefficient, unwashed wool shearing and pure fiber yield, and staple length and pure wool yield can be classified as exhibiting mixed relationship characteristics in some instances.

The mean arithmetic correlation coefficient for intrapleiad connections, indicating the "strength" of the pleiad, is +0.687 ± 0.032. In contrast, the average for mixed type connections is notably lower, at +0.394 ± 0.041. The distribution of interpleiad connections exhibits a very low average value of +0.058 ± 0.044.

The analysis of the bimodal distribution goes beyond merely deciphering the intrapleiad, interpleiad, and mixed relationships among different traits. A noteworthy finding is that the frequency of high correlation coefficient values (the right side of the distribution curve) is observed at a range of 22.2% to 34.2% for different sheep groups. On average, this frequency is about 27.2%, which is roughly one-quarter of the total. This trend might be linked to the inherent nature of the inheritance patterns within the correlation pleiades. Moreover, within the encompassing pool of correlation coefficients considered, the portion of high indicators of correlative variability (on the right side of the distribution) varies across sheep groups, ranging from 44.0% to 57.5%, and averages out to 51.9%, or approximately half. It's plausible that this pattern is also linked to the genetic determination of the magnitude of correlation coefficients within the correlation pleiades encompassing the entire organism.

The data encompassing the genetic correlation calculations for the sheep population at the "Sharbulak" breeding farm and the "Samat" peasant farm, taking into account ewe productivity, is provided in Table 4. The genetic correlation coefficients are categorized into three groups: pure imaginary (resulting from the square root of a negative number), values greater than one, and normal indicators ranging from -1 to +1. In terms of the distribution of these groups of correlation coefficients, there aren't significant differences between the two populations. The share of normal genetic correlation indicators, falling within the range of -1 to +1, averages at 72% for the recorded sheep population at the "Sharbulak" breeding farm. Fluctuations within individual pairs of traits range from 70% to 74%. In the "Samat" peasant farm, these figures are 73%, 60%, and 90%, respectively. The share of purely imaginary genetic correlation coefficients within both farms averages at 16% and 14%, while values exceeding one account for 12% and 13%.

Among the three pairs of traits considered, the highest genetic correlation is observed between sheep's live weight and the unwashed wool shearing. This is closely followed by the correlation between unwashed wool shearing and staple length, as well as the genetic correlation between sheep's live weight and wool length. Notably, an interpopulation difference is evident in terms of a higher genetic correlation between staple length and sheep's live weight within the "Samat" peasant farm.

The coefficients of genetic correlation between the indicators of the productivity of ewes, associated with the determination of the percentage of pure fiber yield and pure wool shearing for the flock of sheep of the "Sharbulak" breeding farm, are shown in Table 5.

In parallel, the frequency of normal genetic correlation indicators was somewhat lower, averaging at 53.6%. Contrastingly, the share of purely imaginary correlation coefficients was notably higher at 32.1%, and the frequency of indicators exceeding one remained at approximately the same level, totaling 14.3%. This distribution pattern closely mirrors the situation observed with the previous three pairs of traits.

It's worth highlighting that a significant degree of parallelism exists between the magnitudes of phenotypic and normal genetic correlations for all 15 pairs of traits. This parallelism is underscored by the comparison of genetic correlation indicators with the values of phenotypic correlation coefficients, both within the group of ewes (r_s = +0.659 ± 0.209) and across all sheep groups in the "Sharbulak" breeding farm flock (+0.646 ± 0.212). The mean genetic correlation value across all considered traits (+0.238 ± 0.077) is only slightly lower than the average phenotypic correlation value among these traits for all sheep groups (+0.258 ± 0.048) and the ewe groups (+0.280 ± 0.037). A distinct discrepancy between the magnitudes of genetic and phenotypic variability is primarily observed in two pairs of traits: unwashed wool shearing and wooliness coefficient (with correlation coefficients of +0.054 ± 0.098 and +0.437 ± 0.033, respectively); and live weight of sheep and pure fiber yield (+0.384 ± 0.070 and 0.004 ± 0.037). If these two pairs of traits are excluded from the analysis, the parallelism between genetic and phenotypic variability becomes even more pronounced both within the ewe group (r_s = +0.786 ± 0.187) and across all sheep groups at the "Sharbulak" breeding farm (r_s = +0.771 ± 0.192). This observation suggests a strong correspondence between the magnitudes of phenotypic and genetic correlations.

However, in a significant proportion of cases (26.0-85.7%, and 43.6% on average), the value of the genetic correlation has a purely imaginary value or exceeds one. To elucidate the mechanisms of the formation of the specifics of genetic correlation, a comparison was made of the gradations of the specifics of this correlation of all parameters that are used to determine the coefficients of genetic correlation, as well as all indicators of phenotypic correlation by groups of registered mothers and daughters. Pure imaginary indicators of genetic correlation were obtained in cases where one of the traits showed a negative "mother-daughter" correlation. The negative value of this correlation may be a consequence of the overdominant and epistatic interaction of genes or the result of a statistical interaction of the genotype and the environment. Although a negative parent-offspring correlation may also arise due to non-random differences in paratypic factors during the formation of the productivity of animals of one generation.

A negative genetic correlation is obtained with a negative total value of reciprocal correlation coefficients between one trait in mothers and another in daughters. Genetic correlations greater than one occur when medium and relatively high reciprocal correlation coefficients between one trait in mothers and another in daughters are combined with a low "mother-daughter" correlation coefficient for the same economically useful traits. This mechanism underlies the very algorithm for calculating genetic correlation as a reflection of the prevailing population ideas about the hereditary determination of the magnitude of phenotypic correlations. The essence of these ideas lies in the fact that the value of genetic correlation finds its expression in the phenotypic as an inversely proportional value in relation to the level of hereditary determination of the diversity of traits in the population.

In this context, particular attention should be given to the results of comparing the gradations of genetic correlation magnitudes between pairs of traits and the actual magnitudes of phenotypic correlations between these traits in mothers and daughters. Theoretically, the genetic correlation's magnitude should reflect the nature of dynamic stability in phenotypic correlation indicators as generations of organisms transition. Consequently, abrupt shifts in genetic correlation values (including purely imaginary, greater than unity, or negative values) ought to impact phenotypic correlation indicators in daughters. However, such patterns are not observed. Across all gradations of genetic correlation for every pair of traits, there are no statistically significant differences in the magnitudes of phenotypic correlation, both for mothers and daughters. This observation suggests, to a certain extent, that there exists independence rather than a strict relationship between the magnitudes of phenotypic and genetic correlation in animal productivity indicators. The established correlation patterns as generations of organisms change are directly intertwined with the issue of correlative variability and selection within sheep breeding.

Table 4. Genetic correlation between the productivity indicators of sheep of the "Sharbulak" breeding farm and the "Samat" peasant farm.

Household	Number of years	The number of "mother-daughter" groups of different years of birth	Number of "mother-daughter" pairs	Number of correlation coefficients				The value of genetic correlation coefficients ranging from -1 to +1		
				total	including			average for all groups	fluctuation by groups of counted sheep	
					pure imaginary	greater than one	from -1 to +1.	$r_9 \pm m_{29}$	min	max
Sheep live weight and unwashed wool shearing										
"Sharbulak" breeding farm	11	30	2255	30	5	3	32	+0.315 ± 0.064	+0.315 ± 0.090	+0.909 ± 0.036
"Samat" peasant farm	9	10	2119	10	2	2	6	+0.341 ± 0.066	-0.618 ± 0.057	+0.833 ± 0.044
Sheep live weight and wool length										
"Sharbulak" breeding farm	11	30	2255	30	3	5	22	+0.099 ± 0.066	-0.737 ± 0.035	+0.800 ± 0.046
"Samat" peasant farm	9	10	2119	10	-	1	9	+0.307 ± 0.065	-0.150 ± 0.055	+0.620 ± 0.050
Unwashed wool shearing and sheep staple length										
"Sharbulak" breeding farm	11	30	2255	30	7	2	21	+0.205 ± 0.064	-0.556 ± 0.059	+0.852 ± 00.31
"Samat" peasant farm	9	10	2119	10	2	1	7	+0.131 ± 0.071	-0.279 ± 0.072	+0.466 ± 0.070

Table 5. Genetic correlation between the productivity indicators of the recorded number of sheep in the "Sharbulak" breeding farm.

Comparable traits	Number of "mother-daughter" groups of different years of birth	Number of correlation coefficients				Coefficients of genetic correlation on average for all groups
		total	including			
			pure imaginary	greater than one	from -1 to +1.	
I – IV	7	7	2	-	5	+0.384 ± 0.070
I – V	7	7	1	1	5	+0.241 ± 0.077
I – VI	7	7	3	-	4	-0.091 ± 0.086
II – IV	7	7	2	1	4	-0.318 ± 0.072
II – V	7	7	1	2	4	+0.345 ± 0.076
II – VI	7	7	3	1	3	+0.054 ± 0.098
III – IV	7	7	2	-	5	+0.263 ± 0.073
III – V	7	7	1	2	4	+0.274 ± 0.071
III – VI	7	7	3	1	3	+0.267 ± 0.089
IV – V	7	7	2	-	5	+0.369 ± 0.070
IV – VI	7	7	4	2	1	+0.670 ± 0.059
V – VI	7	7	3	2	2	+0.498 ± 0.073
Total	-	84	27	12	45	+0.315 ± 0.076

Note: I – sheep live weight; II – unwashed wool shearing; III – wool length. IV – pure fiber yield; V – pure wool shearing; VI – wooliness coefficient.

4. Conclusion

Thus, the rational use of genetic resources of stud rams of fine-fleeced sheep of South Kazakh merino breed of different populations of local selection taking into account the obtained breeding traits will allow to conduct directed selection for obtaining offspring with high genetic potential, and also will provide increase of both meat and wool productivity of merino sheep bred in the region.

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